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Baeticoniscus carmonaensis sp. nov. a new Isopod found in an underground aqueduct from the Roman period located in Southwest Spain (Crustacea, Isopoda, Trichoniscidae)

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Abstract

We use a morphological approach to describe a new species of isopod in the genus *Baeticoniscus*, found so far only in an underground gallery system created during the Roman period, approximately two thousand years ago, located beneath the modern town of Carmona (Seville, Spain). Specimens have been observed inhabiting rotten wood in the aphotic zone. The new species, *Baeticoniscus carmonaensis* **sp. nov.** differs from related species in the presence of the eyes as well as the number and arrangement of the tubercles and ribs on the cephalon and pereion. The description of this new species of *Baeticoniscus* represents one of the few cases worldwide in which the description of a new taxon has been described in a subterranean archaeological site.

Keywords

Crustacea, Iberian Peninsula, Isopoda, taxonomy, Trichoniscidae, urban ecology

Introduction

Nineteen families of terrestrial isopods and 269 species have been recorded in the Ibero-Balearic region, 52 of which were described in the last seven years (unpublished data). Most of these species fit into three families: Armadillidiidae Brandt, 1833, with 41 species; Porcellionidae Brandt & Ratzeburg, 1831, with 76 species; and Trichoniscidae Sars, 1899, with 89 species. Among the trichoniscids, the subfamily Trichoniscinae G.O. Sars, 1899 includes the largest number of species, while the subfamily Haplophthalminae Verhoeff, 1908, is only represented by fourteen species belonging to the following genera: *Baeticoniscus* Garcia, 2020, *Balearonethes* Dalens, 1977, *Graeconiscus* Strouhal, 1940, *Haplophthalmus* Schöbl, 1860, *Iberoniscus* Vandel, 1952 and *Moserius* Strouhal, 1940.

To date, underground ecosystems remain overlooked in conservation policies, and our knowledge of subterranean life is far from complete (Mammola et al. 2019; Nanni et al. 2023). Within these ecosystems, those created by human activities are even less studied, and many of such places often remain unknown. The role that fauna can play in utilizing human-made infrastructures, whether abandoned or still in use, is only now beginning to be properly understood. For example, some amphibians have been detected in abandoned railway tunnels (Herrero and Hinckley 2014), and drainage galleries (Rosa and Penado 2013), and Italian speleologists discovered a new subspecies of beetle, *Boldoria ghidinii ghidinii*, exclusively found in the subterranean dungeons of a castle in Brescia (Giachino and Vailati 2010). In this article, we describe a new terrestrial isopod species based on morphological characters of specimens collected from the only known location for this species, a subterranean gallery system built during the Roman period in Carmona (Seville, Spain). The conservation status of the new species remains unknown, but all specimens were detected at a single point within the artificial gallery system.

Material and methods

Study site and data collection

We conducted this study in the municipality of Carmona (Seville, Spain; 37.472, -5.638; Fig. 1A) (Instituto de Estadística y Cartografía de Andalucía 2022). Here, we specifically explored the so- called '*San Antón water mine*', a complex of underground galleries located beneath the modern town. Designed for the storage and use of groundwater, the system still maintains a permanent stream and was used until recent times to supply water to residents, orchards and hydraulic infrastructures (Naranjo 2017) (Fig. 1B). Recent studies have confirmed the Roman origin of the underground gallery system, possibly dating back to the Republican period, with significant infrastructure development occurring between the 1st and 2nd centuries AD, the peak period of Carmo (the Roman name for present-day Carmona) (Naranjo and Rodríguez 2023a; Naranjo and Rodríguez 2023b). The structure of the mine includes a main gallery or aqueduct, extending 880 meters, which intercepts water currents flowing perpendicularly. It also features five forks and

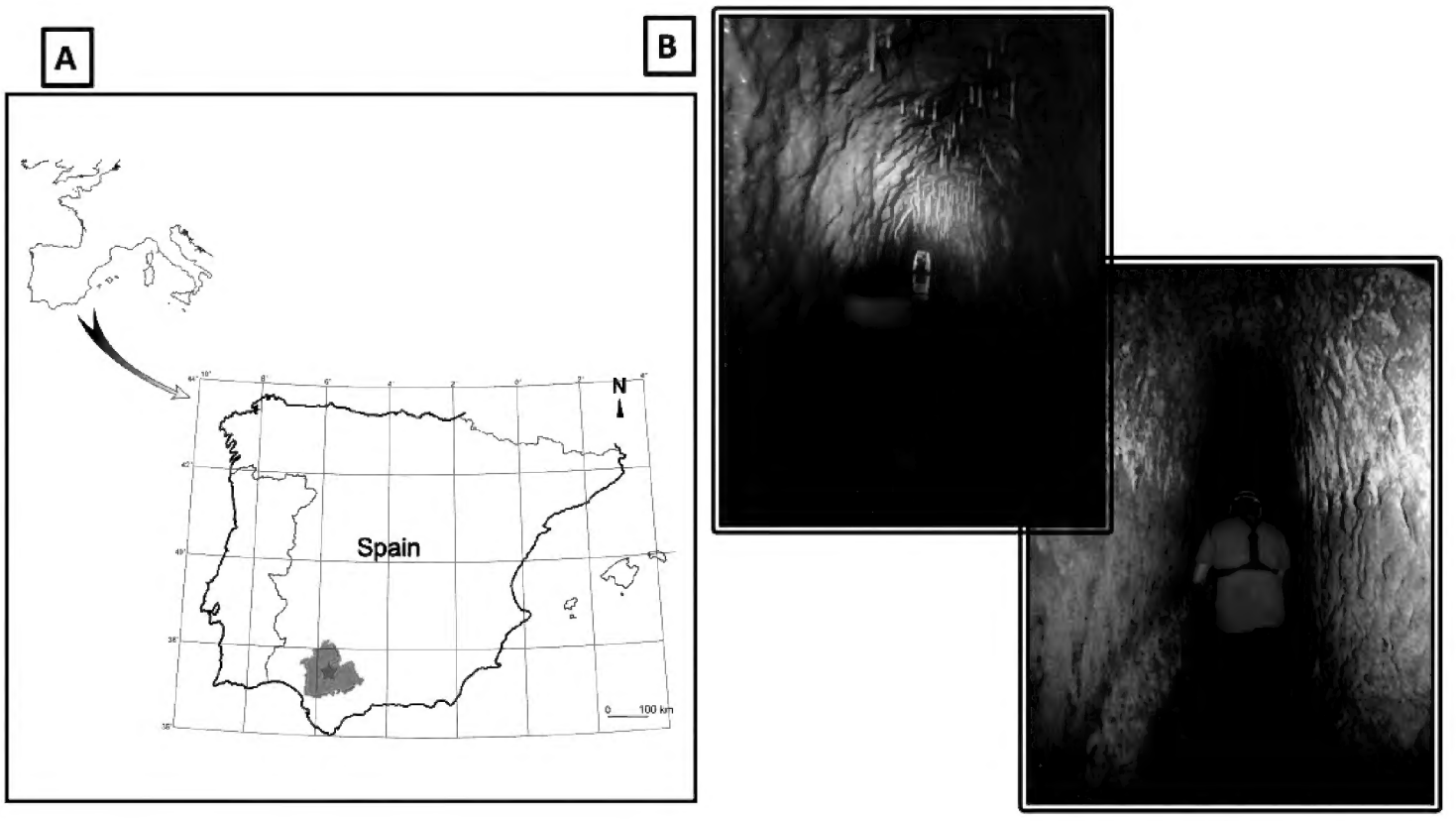

Figure 1. A study area, with the province of Seville in color green and the exact location of Carmona represented with a blue star **B** pictures of the location where the specimens described were found.

three short galleries (see Naranjo 2017 for a detailed description of the mine). Studies in galleries located in adjacent areas have revealed the presence of diverse species both terrestrial and aquatic, including the red swamp crayfish (*Procambarus clarkii*), and snakes such as the horseshoe whip snake (*Hemorrhois hippocrepis*) and the ladder snake (*Zamenis scalaris*) (Naranjo and Rodríguez 2023b). During our fieldwork in the '*San Antón water mine*' we observed Spanish ribbed newts (*Pleurodeles waltl*), the amphipod *Echinogammarus obtusidens* (Gammaridae), American cockroaches (*Periplaneta americana*), the Pholcidae *Pholcus phalangioides* and the exotic spider *Howaia mogera* (Cortés-Fossati et al. 2025).

Morphological analyses and nomenclature

The identification of the specimens was based on bibliographic descriptions. Specimens were collected by hand, without the use of traps, and preserved in 70% ethanol. For microscopic preparations, the synthetic resin DMHF (dimethyl hydantoin formaldehyde) was used. To assist in the identification of the species, several figures were created using both a microscope and a stereomicroscope (Gundlach), each equipped with a 12 MP digital camera (C2CMOS). The drawings were made using the free graphic editor InKscape (https://inkscape.org/es/).

Specimens have been deposited in the isopod collection of the National Museum of Natural Sciences in Madrid (MNCN) and four specimens remain in the personal collection of one of the authors (JC). Specimens of *Baeticoniscus bullonorum* Garcia, 2020 (Fig. 2) were studied to establish the necessary comparisons with the new species described in this work.

Results

Class Malacostraca Latreille, 1802
Orden Isopoda Latreille, 1816
Suborden Oniscidea Latreille, 1802
Family: Trichoniscidae G. O. Sars, 1899
Genus: *Baeticoniscus* Garcia in Garcia et al. 2020

***Baeticoniscus bullonorum* Garcia, 2020**

Material analyzed. • Málaga, Benaoján, Cueva de la Pileta: 1 male and 2 females 04/27/2014, T. Pérez leg., JC402; 5 males and 4 females 04/13/2019, J. Cifuentes and J.T. Bullón leg., JC400.

Remarks. Since this is the other species of the genus to which the new species described belongs, specimens of *B. bullonorum* have been included, along with images (Fig. 2B, C), in order to establish the differences between them.

***Baeticoniscus carmonaensis* sp. nov.**
https://zoobank.org/974EA5B5-E0E2-4E58-A8A5-E4F3D8D28E22

Type material. ***Holotype***: • Seville, Carmona, 37.472, -5.638, Mina de San Antón, 07/27/2022, male, A. Luna, A. Adame, D. León and E. Peña leg., MNCN 20.04/20569.

Paratypes: Same locality and collectors as holotype: • 3 males, 03/12/2021, MNCN 20.04/20598 to 20.04/20600; • 1 female 06/11/2021, MNCN 20.04/20601; • 9 males, 07/27/2022, MNCN 20.04/20570 to 20.04/20578; 07/27/2022, • 2 males, 19 females (2 ovigerous) and 1 panga, MNCN 20.04/20579 to 20.04/20597; • 2 females, leg., JC662.

Etymology. The new species name refers to the town where the species was collected, Carmona.

Type locality. Carmona (Seville, Spain); system of underground galleries (37.471111, -5.642222).

Diagnosis. Cephalon with large tubercles, two elongated on the middle zone and four on posterior edge; pereonites 1 to 6 with 4 ribs and two on seventh; smooth pleon. Eyes of large, black ocellus. Pereopods 1 and 7 without sexual differentiation. Male pleopod 1, with endopod long, biarticulated and ending in hollow and striated conical point; exopod triangular, with protrusion near base. Male pleopod 2 with very long endopod ending in one silk; exopod with long rounded inner tip.

Description. Maximum length: 2.5 mm male; 2.7 mm in a female. Coloration: Specimens examined are colorless, with dark pigmented ocellus Somatic characters: ***Cephalon*** (Figs 2D, E, 3A) with triangular median lobe, large and rounded at end, lateral lobes and mediocre laterals slightly protruding from lateral edge and directed forwards. ***Pereon*** (Figs 2D, 3A) with the pereonites epimera extended as well as the pleonites epimera in the pleon. ***Telson*** (Figs 2D, 3A) trapezoidal, much shorter than posterior edge of uropod protopod, with concave sides and broadly rounded end.

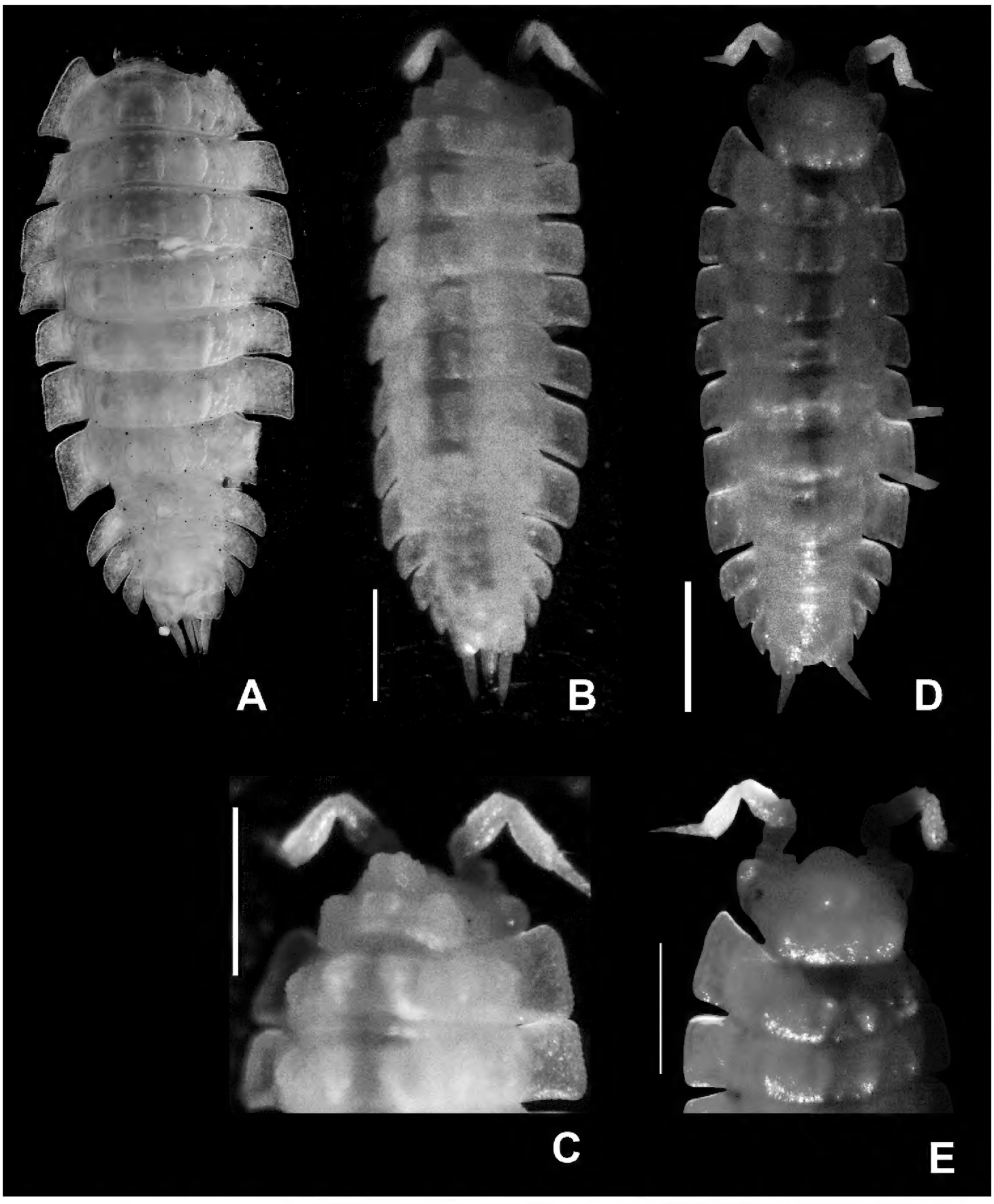

Figure 2. *Iberoniscus breuili* Vandel, 1952, female, MNHN-IU-2013-19986 **A** habitus. *Baeticoniscus bullonorum* Garcia, 2020, male, JC400 **B** habitus **C** cephalon. *Baeticoniscus carmonaensis* sp. nov., male **D** habitus **E** cephalon. Scale bars: 0.5 mm (**B–E**); (**A** sin escala).

Integumentary characters (Figs 2D, E, 3A): cephalon with two small central tubercles, behind median lobe; two large elongated tubercles on middle area and four (2+2) on posterior margin, outer ones larger. Pereonites with four longitudinal ribs (2+2), gradually reducing, pereonite 6 with outer ribes smaller, and pereonite 7 two central ribs pleon. Ocular apparatus (Figs 2D, 3A): formed by large ocellus. Appendages: ***Antennula*** (Fig. 3B) with three segments, basal one stout, second and third thinner and subequal in length;

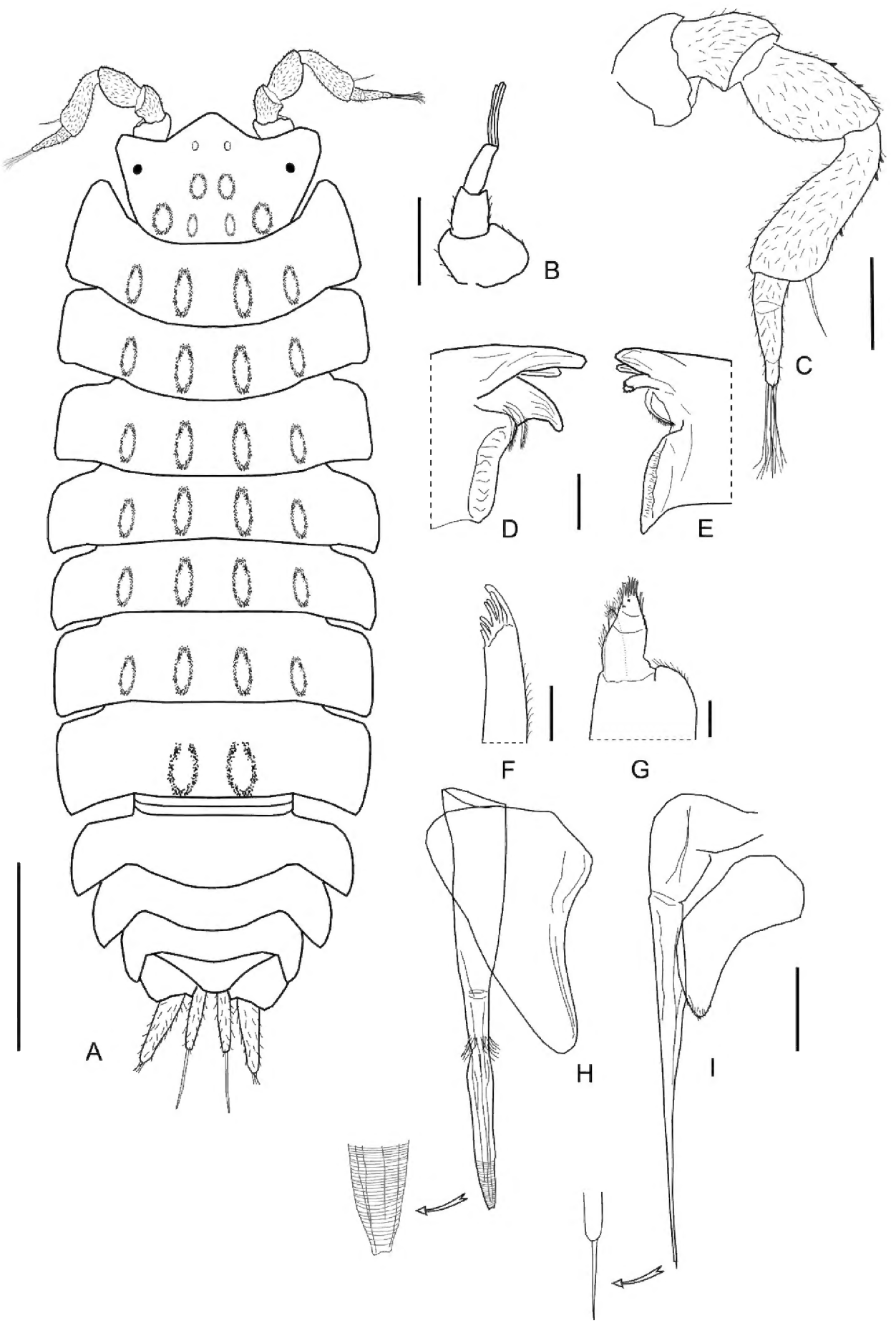

Figure 3. Baeticoniscus carmonaensis sp. nov., male, MNCN 20.04/20598 **A** habitus **B** antennula **C** antenna MNCN 20.04/20601 **D** left mandible **E** right mandible **F** maxillula **G** maxilliped. MNCN 20.04/20598 **H** Pleopod I **I** Pleopod II. Scale bars: 0.5 mm (**A**); 0.1 mm (**C, H, I**); 0.01 mm (**B, D–G**).

third segment with three long terminal aesthetascs. ***Antennas*** (Fig. 3C) with fourth segment stout and with some scaly tubercles on fourth and fifth segments; flagellum of three segments, second segment with a group of aesthetascs. ***Buccal pieces*** (Fig. 3D–G) similar

to that of other species of the genus, with two free penicils on the left mandible (Fig. 3D) and one on the right (Fig. 3E). Maxillula and maxilliped as observed in Fig. 3F, G.

Sexual characteristics of male: Pereopods 1 and 7 without sexual differentiation. Pleopod I (Fig. 3H): endopod long, biarticulated, with long setae at junction of both segments, and ending in hollow and fluted conical point; exopod triangular, elongated, with protruding outer edge near base. Pleopod II (Fig. 3I): endopod very long, sharp and ends in one silk; exopod with long and rounded inner tip; posterior border concave and inner one convex.

Habitat and ecology. Our knowledge of the ecology of *Baeticoniscus carmonaensis* sp. nov. is limited due to the lack of specific studies on the species and the absence of other populations for comparison. *Baeticoniscus carmonaensis* sp. nov., along with others species, thrives in groundwater ecosystems. The only known population of this species has been found in elevated areas within the gallery system, beyond the reach of water floods. All specimens were discovered on or within pieces of rotten wood, likely fallen from wells connected to the underground galleries. When manipulating such wood, specimens were observed moving and hiding within the crevices of this decomposing material.

Conservation. *Baeticoniscus carmonaensis* sp. nov. is known only from the type locality, where the total number of specimens observed by the authors during fieldwork does not exceed 150 –200 individuals. The site remains well preserved, as it receives no tourist or other visits, except for those made for scientific purposes, typically between 0 and 5 per year. However, recent surveys have detected microplastics in the water and sediments, suggesting a potential interaction with this species (unpublished data). Any contamination event or alteration of the environmental conditions could severely affect the only known individuals of the species. Moreover, archaeological activities or other environmental transformations could have similar impacts. Thus, the major threats to the species include increased human presence and the associated impacts of habitat transformation and depletion.

Family Platyarthridae Verhoeff, 1949
Genus *Platyarthrus* Brandt, 1833

***Platyarthrus caudatus* Aubert & Dollfus, 1890**

Material examined. • Seville, Carmona, system of underground galleries from the Roman period, 07/27/2022, 3 females and 1 panga, A. Luna, A. Adame, D. León and E. Peña leg., JC663.

Comments. This species is found in Algeria, Tunisia, Spain, France, Italy and the Mediterranean islands of Sardinia, Corsica and Sicily (Vandel 1962; Achouri et al. 2008; Abidi and Hamaied 2023). In the Ibero-Balearic area, it has been cited from Gerona, the Balearic Islands, Jaén and Málaga (Pablos 1964; Cruz 1991b; Garcia and Cruz 1996; Garcia 2009, 2013, 2019). It is cited here for the first time in the province of Seville.

Discussion

The subfamily Haplophthalminae Verhoeff, 1908, within the family Trichoniscidae G.O. Sars, 1899, includes genera whose species exhibit an integument characterized by prominent tubercles. The differences in the ornamentation patterns of many of these species are minimal, which is why Schmalfuss et al. (2004) recommended a review of this subfamily. Additionally, the differences in the secondary sexual characters, mainly in the first two pairs of pleopods of the males, are also usually small, complicating the identification of specimens.

Until now, fourteen species belonging to six genera of this subfamily are known in the Iberian Peninsula:

Balearonethes Dalens, 1977 with *B. sesrodesanus* Dalens, 1977 from the Balearic Islands (Dalens, 1977; Cruz, 1991a).

Graeconiscus Strouhal, 1940 with *G. gevi* Garcia, Miralles-Núñez & Pérez-Fernández, 2020 from Málaga (Garcia et al. 2020).

Haplophthalmus Schöbl, 1860, the most important in terms of the number of species, with *H. alicantinus* Cruz & Dalens, 1989 from Alicante (Cruz and Dalens 1989; González Silvestre 2015); *H. asturicus* Vandel, 1952 from Asturias (Vandel 1952; Cifuentes et al. 2021); *H. chisterai* Cruz & Dalens, 1989 from Alicante and the Balearic Islands (Cruz and Dalens 1989; Cruz 1991a; Cifuentes 2021b); *H. danicus* Budde-Lund, 1880 with a wide distribution area, as it has been reported from Bizkaia, Cantabria, Barcelona, the Balearic Islands, Orense, Pontevedra, Seville, Tarragona and Teruel (Arcangeli 1924; Schmölzer 1955, 1971; Cruz 1991a; Garcia and Cruz 1996; Barrientos 2005; Garcia 2009; Gregory et al. 2012; Cifuentes 2019, 2021a; Cifuentes and Tinaut 2019; Cifuentes et al. 2021); *H. gibbus* Legrand & Vandel, 1950 from the Balearic Islands (Vandel 1960); *H. mengii* (Zaddach, 1844) from Barcelona, Bizkaia, Cantabria, Gipuzkoa Girona and Navarra (Arcangeli 1924; Cifuentes et al. 2021); *H. siculus* Dollfus, 1896 from Girona and Tarragona in Spain, Faro and Setúbal in Portugal (Vandel 1946; Cruz 1991a); *H. transiens* Legrand & Vandel, 1950 from Castellón and Málaga (Vandel 1952, 1960; Cifuentes 2021b) and *H. valenciae* Cruz & Dalens, 1989 only known from Valencia (Cruz and Dalens 1989; González Silvestre 2015).

Iberoniscus Vandel, 1952 with *I. breuili* Vandel, 1952 from Cádiz and Málaga (citation that we consider doubtful as stated below) in Spain, and from Gibraltar (Vandel 1952).

Moserius Strouhal, 1940 with *M. inexpectatus* Reboleira & Taiti, 2015 from Santarém in Portugal (Reboleira et al. 2015).

Finally, the genus *Baeticoniscus* Garcia, 2020, was monospecific until this study, with *B. bullonorum* Garcia, 2020, as its only representative. Garcia (2020) described *B. bullonorum* from 31 specimens, 10 males and 21 females, from Cueva de la Pileta, located in Benaoján, province of Málaga (Spain) (Garcia et al. 2020). *Baeticoniscus bullonorum* is characterized by the presence of prominent tubercles on the cephalon, 4 ridges (2+2) on pereonites 1 to 6, and 2 ridges (1+1) on pereonite 7, a smooth pleon, and striations on the tip of the endopod of the male's first pleopod. All these characteristics are present in *Baeticoniscus carmonaensis* sp. nov., which justifies its classification within this genus.

From the same Cueva de la Pileta, Vandel (1952) studied five specimens, two males and three females, which along with other specimens from the Cueva de las Motillas in Jerez de la Frontera (Cádiz) and from the Old St Michel's Cave in Gibraltar, were used for the description of *Iberoniscus breuili* Vandel, 1952. A comparison between the descriptions of both species, *I. breuili* and *B. bullonorum*, reveals important differences between them in the ornamentation of the integument. *I. breuili* presents five pairs of ribs on the pereion (Fig. 1A) and a tubercle in the pleonite 3, whereas *B. bullonorum* has two pairs of ribs on the pereion and lacks a pleon tubercle (Fig. 2B, C). Note also the presence of a developed carpal lobe on the pereopod 7 of the male in *I. breuili*, which is absent in *B. bullonorum*. However, the drawings of the cephalon tubercles provided by both authors for their respective species are very similar (see Vandel 1952 p. 350 and Garcia 2020 p. 261).

We studied 12 specimens (six males and six females) of *B. bullonorum* from the Cueva de la Pileta, consistent with the description of this species by Garcia (2020). These specimens exhibit the same arrangement of tubercles on the cephalon (Fig. 2C) as *I. breuili* described by Vandel, but without the accessory ribs on the pereion and the large tubercle on pleonite 3 characteristic of that species. In the Vandel collection deposited at the Muséum national d'Histoire naturelle (MNHN) in Paris, under reference MNHN-IU-2013-19986, there is a single tube containing several poorly preserved specimens of *I. breuili* from two of the localities mentioned by Vandel (1952). Of one of these specimens, which lacks the cephalon, have been photographed (Fig. 2A) and the accuracy of Vandel's description can be confirmed in relation to the ribs of the pereion and the tuberculation of the pleon, but as it lacks the cephalon, the tubercles cannot be observed. As noted earlier, since the only preserved specimens belong to the two localities are mixed, it is not possible to determine which cave the specimen in the photograph originates from. We consider it unlikely that two species from different genera, in which the integument ornamentation is a crucial character, would exhibit the same arrangement of tubercles on the cephalon. Since all 43 specimens studied from the Cueva de la Pileta by both Garcia (2020) and us undoubtedly correspond to *B. bullonorum*, it is highly probably that *I. breuili* is not present in the Cueva de la Pileta as Vandel (1952) said. It is likely that the specimens Vandel studied from this locality actually belong to *B. bullonorum*. Thus, until the Cueva de las Motillas in Jerez de la Frontera (Cádiz) and the Old St. Michael's Cave in Gibraltar can be revisited, *I. breuili* would only be known from these caves, not from the Cueva de La Pileta in Málaga.

Baeticoniscus carmonaensis sp. nov. is differentiated from *B. sesrodesanus*, as the latter species has spiny tubercles arranged in several rows, not forming ribs. In *G. gevi* and *I. breuili* there is a large tubercle on the third pleonite, and in *M. inexpectatus* there are two, neither of which are found in *B. carmonaensis* sp. nov. In *Haplophthalmus* species, the tubercles are much weaker than those found in *B. carmonaensis* sp. nov. Finally, *B. carmonaensis* sp. nov. (Figs 2D, E, 3A) differs from other species in the genus *Baeticoniscus* due to the presence of the ocular apparatus, the absence of lateral roughness and the cephalon tubercle, as it only has two elongated median tubercles and four posterior ones, compared to the bilobed frontal tubercles of *B. bullonorum* (Fig. 2B, C).

The description of this new species is significant for different reasons. Beyond enhancing our understanding of underground biodiversity and European terrestrial isopods, this discovery represents one of the few descriptions of a new species in an urbanized area. Considering the growing effort for a greater recognition of subterranean ecology, the discovery of a new species in an urban underground environment- alongside other species as *Platyarthrus caudatus*- can help draw attention to these often overlooked ecosystems, particularly in cities with archaeological sites, canals, and tunnels. Regarding the unknown conservation status of the species, increasing research is demonstrating how cities can play a role in nature conservation, sometimes being the main habitat for species (Luna and Rausell-Moreno 2024). For *Baeticoniscus carmonaensis* sp. nov. future surveys in other underground environments in southern Spain could confirm its presence in new cave systems, both artificial and natural, which would help inform conservation measures with more comprehensive knowledge. In any case, the species is currently only known from a single population, found in decaying wood, consisting of several hundred specimens.

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